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NEWER EXPERIMENTS ON THE TECHNOLOGICAL VALUE OF GREEK DURUM WHEAT

[Following is a translation of an article by B. Kokolios, Director of the Wheat Institute, Thessaloniki, and Technology Laboratory of the Wheat Institute, in the Greek-language journal Gheoponika (Agriculture), Vol 94-95, Thessaloniki, May-June 1962, page 1-10.]

Summary

Reference is made to the special technological characteristics of the wheat tr. Durum, which lead to its exclusive use for the production of semolina flour and macaroni products. Bibliographical data are summarized concerning factors which affect the industrial value of the products (varieties, soils, fertilizers), and mention is made, according to latest available data, of qualitatively-improved producing varieties. Concerning the planned acreage expansion of Greek durum earmarked for export, the following points are studied in this article:

1. The qualitative yield and classification of the new improved varieties, as well as of the latest experimental varieties of Greek durum wheat, based on samples taken from five experimental plots.

are made

Following measurements involving color, one hundred liter weight, weight of 1,000 kernels, ash and protein content, plastic qualities of semolina and color of semolina in B carotene (p. p. m.) (parts per million), three varieties:

Γ-58128, Γ-58301, Γ-46049 (Γ= gamma), are listed at the top. The newest varieties, tried for the first time, did not show up as well, with Γ-63848 and Γ-66290 being the best among them.

2. The favorable influence of fertilizing with 3 + (2 + 1) - 6 - 0 upon the above chemical-technological characteristics, which is considered significant as to the protein content of the wheat and the plastic qualities of the semolina flour, as well as the relative influence of the time of harvest.

3. Finally, the data of ~~this paper~~ are compared to parallel values of well-known foreign hard wheats, (Amber Durum), (Spanish Hard Wheat), and methods are suggested for the systematic control of Greek durum wheat and particularly for that wheat which is destined for export.

(End of Summary)

Botanically, we know that Durum hard wheat comprises a particular species, characterized by 28 chromosomes, as against the 48 chromosomes of soft wheat (Vulgare) (1). Regardless of this basic difference, Durum wheat is further characterized by other properties, some of which concern the technology of the product. It is mainly due to these qualities that Durum wheat is utilized for the production of semolina flour and macaroni products.

After milling, Durum wheat produces a flour with flowing gluten, qualities of fluidity which are substantially inferior, and a bread-making capacity much inferior to that of Vulgare wheat, and it is thus not utilized for bread-making. However, because of their chemical composition, Durum wheats are richer in total protein, fats, inorganic salts, cellulose, dissolving sugars, dextrin, and the fatty-soluble yellow color of the endosperm, due to B carotene (provitamin A).

Durum wheat is unique in terms of its structure and mechanical qualities. The protein and starch molecules of the endosperm are distributed and arranged homogeneously, thus creating an endospermic whole which is characterized by great compactness and hardness, as well as crystalline section and texture. The result of this arrangement of molecules is the high weight per hundred liters, the high specific gravity, the increased weight of 1,000 kernels, and the great yield in semolina flour which is the raw material for macaroni products.

During production of semolina flour, the compression of the endosperm leads mainly to the production of small or large grains of semolina and only to a very limited extent of a certain quantity of very inferior flour. Considering the conditions under which the newer macaroni producing mills operate (2), they require as raw material semolina from the second commercial category, which harmoniously combines the best possible physical, chemical and plastic qualities.

Therefore, the desirable semolina should come from Durum wheat which has the following characteristics: amber color, the highest possible weight per one hundred liters, crystalline section, great hardness of the endosperm, highest protein content, lowest possible ash content, highest possible yield in yellow semolina, and good plastic qualities. This yields the best possible macaroni products.

Two groups: the A. A. C. C. (4) ([Note]: American Association of Cereal Chemistry) and the I. G. G. (5) ([Note]: Internationale Gesellschaft fur Getreide Chemie - Vienna -), are working with the foremost institutes and wheat products industries towards the development of methods and controls concerning the manufacturing value of Durum wheat and its products. The above is significant in view of the fact that today nowhere is there any uniformity of approach concerning appropriate laboratory methods.

Bibliographical Study

Concerning the development and choice of strains of wheat, and the effect of geography and fertilizers on the chemical composition of the kernel, we can be totally guided by findings published in the latest study of the Foundation under the title of "Bread-making (panifiable) qualities of certain varieties of Greek wheat" (6). In addition, we can refer to the more specific studies and communiques of the Wheat Institute concerning the effect of fertilizers, in which it is stated that nitrogen fertilization, in particular the application of nitrogen in the form of nitrate in the spring, contribute to the increase of the protein content and the improvement of the fluidity characteristics of the product (7). An extensive bibliography is devoted to the above studies. Beyond that, research dealing with Durum wheats is being directed now to factors affecting compactness, hardness, crystalline qualities of the kernel, yield in semolina flour and, as far as it is possible to ascertain, characteristics of the macaroni-products deriving from it. We learn from a relevant article of Professor Fabriani and his co-workers (8) that the most important laboratories in the world do not follow similar methods of research.

The problem of variation in the particular properties of Durum wheat as they relate to strains and ecological conditions has been of special interest to international research. One phenomenon in particular was noticed and studied, namely, the appearance totally or in part of flour-bearing kernels, which is internationally known as "mitadinage". This phenomenon involves a change in the desired structural condition of the kernel. According to Leclere's (9) work, there is a correlation between the protein content and percentage of crystalline kernels, and an increase of the flour-bearing kernels following an increase in rainfall or irrigation. We notice, moreover, the beneficial effect of previous leguminous cultivation and the resultant supplying of nitrogen, and it appears that the shorter the growing period, the larger the nitrogen content and hardness of the kernels.

According to Persival, heavy soils contribute to the appearance of "mitadinage" (1), whereas, as far as varieties are concerned, it appears that those most susceptible to "mitadinage" are the most productive, the most desirable and the best adapted (1). Christiansen, Weniger (10) and Emre, after painstaiking research in Turkey, reached the conclusion that the appearance of "mitadinage" is favored by heavy soils, fertility of the area, rainfall in combination with low temperatures, irrigation, and all the factors which lengthen the biological cycle of the plant. The latest research by Sallans and Simmonds (11) correlates the yield with "mitadinage," unless a factor subject to variation is the nitrogen present.

Nitrogenous fertilizing applied on the surface until flowering limits the appearance of "mitadinage" without a decrease in yield. The above conclusion has been reached by other researchers (12) (13). According to E. Valdeyron and Seguela (17), who drew up the most complete bibliography and experimental study on the question of "mitadinage," and more generally on factors affecting the commercial value of Durum wheat, the desired mechanical characteristics of the kernel (hardness, crystalline quality, resistance to breaking), the protein content, and plastic qualities of the resulting semolina flour are improved principally by the following: 1. the creation or selection of the proper strains; 2. the abundant application of basic nitrogenous fertilizer or green fertilizer, essentially a surface application of nitrogen both until flowering and shortly before the drying out of the flowers, since the structural damage and the ensuing qualitative decrease is due to nitrogen shortage during the above-mentioned periods. If, during the ripening period, the kernel enters into contact with water (for example, because of rain), it assumes a specific aspect, similar to the phenomenon of "mitadinage". However, the "washed" kernel undergoes only an undesired structural change which is not accompanied by a decrease in its protein content. Naturally, the damage caused by washing, with a resultant decrease in the semolina yield, cannot be dealt with by fertilizer application.

The Evolution of Research

The Wheat Institute, aside from its above-mentioned research on fertilizers, has made further advances in the study of the technological value of the Greek durum wheat (14), and in particular of the improved varieties, among which are varieties Γ-46049, Γ-58301, Γ-58128. These strains are in the seed-production stage and show a very satisfactory qualitative yield. Similar results are apparent in the related studies made by the Special Laboratory of the Ministry of Commerce (20).

Broader horizons have already been opened for the expansion of Greek Durum wheat acreage, aimed at increasing the production of macaroni products and their sale in the world market as a result of their satisfactory industrial value. Similar thoughts and perspectives are developing in other countries of the Mediterranean basin (North Africa, Middle East, Italy, France).

In view of the above, efforts applied to Greek Durum wheat aimed at uniformity and improvement of its qualities are expanded by developing new strains of Durum, setting up of special experimental plots of Durum wheat, experimental applications of fertilizers, and adopting, in the laboratory, the newest applications of chemical-technological methods (see methods), in conjunction with recently developed equipment.

At the present time, research work covers two areas, which will be described under (A) Strains, and (B) Fertilizers.

A) Strains

During the period 1960-1961, five special experimental plots were set up in Thessaloniki, Dhourouti, Larissa, Kopaida, and Messara (Crete), from whose production 12 varieties were specifically studied. Among them, we mention here the improved Γ-5770, Γ-46049, Γ-58128, Γ-58301, and some newer ones which have been technologically tested because of their encouraging agricultural characteristics. The results obtained from laboratory analyses of the relative samples are given in tables 1A, 1B, 1C, 1D, 1E.

B) Fertilizers and Date of Harvest

Two experimental fertilized fields were set up during 1960-1961 in Thessaloniki and Nea Zoi under trial fertilizing with 3 + (2 + 1) - 6 - 0, one variety (Γ-58128), the application of four cuttings and experimental parceling "split-plot" (one strain, two applications of fertilizer control + trial, four cuttings, three repetitions.) The fertilizing consisted of: A) basic application of sulphuric ammonia and six units of diluted phosphate and, B) surface application of calcium nitrogen ammonia in January and February. The production from both experimental plots, amounting to a total of 48 samples (2 x 2 x 2 x 3), was examined in the laboratory. These data are presented in Tables IIa and IIb.

Discussion

A. Strains - Geography

The strain Γ-58128 stands out among the improved varieties of Durum which have been earmarked for production, because of its very satisfactory industrial value. This variety is at the head of all the others from all basic criteria in each experimental plot, and it shows excellent plastic qualities in its semolina flour. Next comes the variety Γ-58301, and then follows the variety Γ-46049, whose protein content was not satisfactory. The variety Γ-5770 (Limnos) was found wanting in specific basic traits concerning the crystallinity of the kernels and the plastic qualities of the semolina.

The locally found strains, including YΓ11 (Deves) and Roussias, never came close to the leading variety Γ-58128 for most characteristics to the other two, but they surpassed Γ-5770 in all comparisons. The seven newly-tested strains

(Γ-63848, Γ-63849-IA3, Γ-65874, Γ-66187, Γ-66287, Γ-66289, Γ-66290) did not evidence superior characteristics. Even though they were not found inferior as to color, one-hundred-liter weight, weight of 1,000 kernels, crystallinity of kernel, ash content, and color of semolina or protein content, they showed a low semolina yield, and had insufficient plastic qualities not generally surpassing those of the strain Γ-5770. In order of quality, the first three of the above are: 1) Γ-66187, 2) Γ-66290, and 3) Γ-66289.

Significant differences in different experimental plots were observed among the data collected for this strain. The most substantial variation took place in the values dealing with the weight of 1,000 kernels, ash content, protein complex and plastic qualities of the semolina. In terms of qualitative yield, the experimental plots may be ranged in the following order:

1) Messara experimental plot, 2) Kentrikou experimental plot, 3) Larissa experimental plot, 4) Dhourouti experimental plot, 5) Kopais e-perimental plot.

The production of the first three plots is very satisfactory, whereas the production of the last two does not appear desirable for industrial use. This means that the choice of proper terrain is very significant, in order to guarantee the efficient combination of yield and quality of product.

Table 1F was drawn up for purposes of comparison. It contains values presented in this paper which describe the most important varieties, and the characteristic values of Spanish Durum wheat imported into Greece two years ago. Finally, Table 1F contains the range of certain values of Amber Durum wheat, which today is considered best for industrial purposes. These data were derived from the publications of the Winnipeg (Canada) [see note] Wheat Institute, in which Canadian export wheat was subjected to chemical-technological study on a quarterly basis.

[Note:] The values of Amber Durum are determined according to methods used by the Greek Wheat Institute. Beyond that, the Wheat Institute in Winnipeg determines the plastic qualities by means of a special farinograph, and engages in experimental production of macaroni products (16).

From this comparison, the following conclusions are reached:

The superiority of Canadian Durum wheat is due to the achievement, after long experimentation, of standardization of production. The basic technological characteristics of the wheat are kept within a very narrow range which is very favorable to utilization by industry, independent of geographical and time factors.

A one-hundred-liter weight above 79, a protein content above 14, a corresponding satisfactory range of the color of the endosperm, and high plastic qualities guarantee for Amber Durum wheat a consistently high yield in semolina having high nutritional value and macaroni-making qualities. However, and in spite of existing opinions on this subject, the crystalline kernels of Amber Durum show a great range of variability. Spanish wheat does not present any particular interest.

Compared to the above varieties, Greek Durum wheat presents wide variations in relation to geography and season. It ranges in quality from as good as Amber to unsatisfactory, due to the peculiar climatological and geographical heterogeneity of Greece.

In spite of the above, the average level of the Greek varieties remains very satisfactory.

B. Fertilizers - Mowings

Factors affecting the color of the kernel, the one hundred liter weight, the weight of 1,000 kernels, and the ash content were so much due to fertilizers as to the time of harvest. This factor has a direct hearing on: 1) the protein content of the kernel, 2) the plastic properties of the semolina (energy - greatest height of the extansiogram) (see methods, 3) and the color of the semolina spectrophotometrically determined, as given in Table IIc, which includes average values and S. S. D.

Comparable to our similar research on Vulgare wheat (7), significant and substantial differences affecting the protein complex and plastic properties, independent of harvest, were noted for fertilizers.

The time of harvest, dependent on the humidity condition of the kernel, is relevant. A decrease in the protein content of the kernel has been noticed in all cases from the first to the last harvest. This decrease was found to be significant in the Nea Zoi experimental plot (fertilizers having been applied).

On the other hand, the extansiographic energy comprising the plastic properties of the semolina assumes its greatest value between the second and third harvest, except in the case of the Kentrikou experimental plot (fertilizer having been applied).

The above data, along with the observed decrease in the total protein content with respect to date of harvest, may suggest exploring the advisability of harvesting hard wheat when the average humidity of the kernel is greater than the usual one, and within a range of about 14-18%. The application of fertilizer contributed appreciably, regardless of time of harvest, to the maintenance of the color of the semolina within desirable limits comparable to the characteristics of Amber Durum. Concerning the percentage of crystalline kernels, the variations which were expected from fertilizer application were not observed (17). This is admittedly due to the fact that the proper date and quantity of fertilizer to be applied superficially has not been determined. The research effort to the Wheat Institute is now being applied in this direction.

C. Concerning the whole area under study

Concerning the existing need for a systematic technological control and standardization of Durum wheat, the following could be adopted in view of our ecological conditions:

1. During the harvesting of hard wheat, in addition to establishing the one-hundred-liter weight and the crystallinity of the kernels, determination must also be made, by means of dry analysis of standard wet analysis, of the protein content of the ashes and of moisture for the evaluation of results

2. More specifically, large samples of Durum wheat earmarked for export must be tested in a more systematic way, as the increasing availability of equipment permits, by means of special tests and semolina-making and macaroni-making test batches which the Wheat Institute is gradually including in its procedures.

The analyses, tests and relative criteria applied for this purpose are as follows: [Note:]

[Note:] The proposed analyses and tests go beyond those required by the existing Agricultural Code, and they represent a selection or application or methods used by researchers Anderson (Canada), Guneo (Italy), Faoriani (Italy), McKay (England), Matweef (France), Navellier (France), Palshenke (West Germany), Silvela (Spain), Schmutz (Switzerland), and Thomas (East Germany), as presented to the Vienna Conference of ths I.G.G. in 1960 (5) (8).

Tests on wheat	Cat. A1	Cat. A2
Color (see methods)	A or B	--
-- 100 liter weight	≥78	≥74
-- 1,000 kernel weight, dry analysis	≥35	≥30
-- Crystalline kernels	≥80	≥65
-- Protein content (5.7 xN) dry analysis	≥12%	≥10%
-- Ashes dry analysis	≤1.6%	≤ 2.0%

Tests on semolina	Cat. A1	Cat. A2
-- Color in B carotene, dry analysis (p.p.m.)	4--6%	--
-- Energy, extansiographic method	≥30	≥15

-- Lipoxydation (The determination has a particular value for the semolina intended for macaroni products, but the relative method is still under study everywhere).

Tests on products of experimental macaroni-making

-- Taste and odor before and after boiling:	Pleasant
-- Surface	Smooth, without roughness or breaks
-- Cut	Crystalline
-- Color (evaluated before and after boiling)	Yellow - amber and not ash-colored, capable of being objectively tested by means of the proper analytical method.
-- Boiling trial -- Time	Within 20 minutes at most, giving an elastic product not sticky or runny.

-- Boiling trial -- Swelling	After boiling the volume should double, and the absorbed liquid must correspond to one half the weight of the sample before boiling.
-- Percentage of material contained in the water after the boiling trial	7% (for determination of solid remnant)
-- Quality indicator Guneo (Italy)	$Q = \frac{T.A\gamma.A\rho.}{S}$
Whereas:	Q = Quality indicator T = time of boiling in minutes $A\gamma$ = solid remnant found in boiled water $A\rho$ = absorption of water

METHODS

The laboratory methods applied to this study, most of which have been presented in detail in the general or special articles and journals of Food Chemistry or of the Chemistry and Technology of Wheat, are hereby greatly summarized:

1. Weight of 1,000 kernels: By counting of 500 and weighing.
2. 100-liter weight: By special arrangement (4).
3. Color of kernels: estimated as follows (A: yellow, B: amber, C: reddish, D: dark red).
4. Moisture: According to Brabender at 130° C/Ih (27).
5. Ashes: At 585° C/24h (4).
6. Protein content (N x 5.7): A.A.C.C. (Kjeldahl) (4).
7. Extansiography on semolina to determine plastic properties (energy - greatest height):

   The alveographic method demonstrated by the Chopin Company according to the requirements of the Comite Professionnel de la semoulerie francaise (2) (Professionnal Committee of French Semolina makers) applied to the study of French Durum wheats cannot be utilized for the good quality Greek varieties because of the limited height potential of the Alveograph.

In view of this, the method was adapted to utilize the Brabender extansiograph with great success without any change of conditions. (Water 45%, without NaCl, applied to 15% humidity unsalted semolina, kneading in a farinograph and homogeneization for eight minutes, taking of sample of 150 grams of wet semolina paste, and extansiography after one half-hour stay in the kneading chamber of the extansiograph.)

8. Experimental production of semolina:

Achieved in a Brabender automatic test mill especially set and fed with hard wheat having a moisture content of 16.5%.

The semolina achieved after sifting and separation from the residue and flour corresponds in terms of the size of the grains to the second and third commercial grades. The yield obtained, which fluctuates between 45-55%, is indicative and does not reflect the commercial yield.

9. Color of semolina;

According to the Ferrari method applied to the chemistry of wheats (19), five grams of semolina are soaked for one night in 25 cubic centimeters of butyl alcohol and are analyzed on the following day.

The same is studied in the Beckman B spectophotometer and has a wave length of 236 m. (Yield in B carotene p.p.m.)

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Appendix: Tables

Table 1a: Experimental Plot
Kentrikou

(1)		(2) ΕΠΙ ΣΙΤΟΥ						(3) ΕΠΙ ΣΗΜΙΔΑΛΕΩΣ			
	(1) ΠΟΙΚΙΛΙΑΙ	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1	ΥΓ-11	Β	76^{50}	39^{31}	86	12^{66}	1612	459	33^{5}	360	6^{38}
2	Γ-5770	Α	76^{50}	38^{79}	84	11^{17}	1453	532	19^{5}	320	7^{40}
3	Γ-46049	Β	77^{73}	42^{10}	85	9^{20}	1597	52^{0}	36^{0}	380	5^{89}
4	Γ-56128	Β	77^{50}	40^{09}	95	13^{70}	1587	52^{0}	51^{0}	400	4^{98}
5	Γ-58301	Β	76^{50}	38^{18}	88	11^{42}	1625	52^{3}	40^{0}	360	5^{87}
6	Γ-63848	Α	77^{25}	36^{72}	60	11^{28}	1519	538	-	-	7^{06}
7	Γ-63849-1Α3	Α	77^{75}	39^{53}	53	10^{23}	1359	49^{0}	10^{5}	220	7^{56}
8	Γ-65874	Β	77^{00}	39^{58}	82	11^{19}	1305	44^{0}	14^{0}	180	6^{31}
9	Γ-66187	Β	77^{50}	33^{31}	83	11^{54}	1378	45^{2}	11^{0}	260	5^{63}
10	Γ-66287	Β	79^{50}	39^{53}	91	11^{60}	1286	45^{1}	22^{0}	260	6^{15}
11	Γ-66289	Β	78^{00}	38^{03}	85	13^{57}	1301	44^{8}	26^{3}	280	5^{87}
12	Γ-66290	Β	78^{30}	43^{43}	89	12^{79}	1345	42^{2}	17^{0}	280	6^{77}

Table 1b: Experimental Plot
Messara

(2)		(2) ΕΠΙ ΣΙΤΟΥ						(3) ΕΠΙ ΣΗΜΙΔΑΛΕΩΣ			
	(1) ΠΟΙΚΙΛΙΑΙ	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1	ΕΝΤΟΠΙΟΣ	Α	78	50^{60}	63	12^{60}	1725	48^{9}	28^{3}	380	3^{35}
2	Γ-5770	Β	80	50^{51}	88	11^{62}	1579	50^{0}	12^{0}	500	5^{16}
3	Γ-46049	Β	80	48^{44}	71	9^{78}	1501	50^{3}	27^{0}	380	5^{19}
4	Γ-56128	Β	80^{5}	48^{40}	94	15^{00}	1673	51^{5}	42^{5}	420	4^{72}
5	Γ-58301	Α	81^{5}	48^{10}	91	12^{36}	1596	52^{0}	35^{5}	420	5^{64}
6	Γ-63848	Α	80^{5}	47^{04}	78	11^{45}	1592	52^{0}	18^{5}	320	6^{05}
7	Γ-63849-1Α3	Α	81	47^{16}	92	9^{29}	1474	50^{5}	15^{0}	260	6^{42}
8	Γ-65874	Α	80	47^{75}	90	12^{21}	1669	45^{0}	11^{0}	260	5^{38}
9	Γ-66187	Β	79^{5}	43^{30}	92	11^{31}	1715	50^{0}	[illegible]	340	4^{33}
10	Γ-66287	Β	81	51^{36}	98	10^{06}	1677	49^{5}	21^{0}	500	5^{99}
11	Γ-66289	Β	80	47^{73}	97	12^{28}	1744	48^{5}	10^{0}	320	4^{76}
12	Γ-66290	Β	80^{5}	54^{71}	94	12^{93}	1680	51^{5}	21^{0}	300	4^{98}

[See legend for tables and figures on last page]

Table 1c: Experimental Plot
Larissa

①	(1) ΠΟΙΚΙΛΙΑΙ	(2) ΕΠΙ ΣΙΤΟΥ						(3) ΕΠΙ ΣΕΜΙΔΑΛΕΩΣ			
		ΧΡΩΜΑ (4)	ΕΚΑΤΟΛΙΤΡΙΚΟΝ ΒΑΡΟΣ ΕΠΙ ΞΗΡΟΥ (5)	ΒΑΡΟΣ 1000 ΚΟΚΚΩΝ ΕΠΙ ΞΗΡΟΥ (6)	ΚΟΚΚΟΙ ΥΑΛΩΔΕΙΣ ΕΠΙ % (7)	ΠΡΩΤΕΙΝΙΚΟΝ ΠΕΡΙΕΧΟΜΕΝΟΝ ΕΠΙ ΞΗΡΟΥ (8)	ΤΕΦΡΑ ΕΠΙ ΞΗΡΟΥ (9)	ΑΠΟΔΟΣΙΣ ΕΙΣ ΣΕΜΙΔΑΛΙΝ (10)	(14) ΕΚΤΑΝΣΙΟΓΡΑΦ: ΕΝΕΡΓΕΙΑ (11)	ΜΕΓΙΣΤΟΝ ΥΨΟΣ (12)	β-ΚΑΡΟΤΙΝΗ (p.p.m.) ΕΠΙ ΞΗΡΟΥ (13)
1	ΥΓ-11	A	77^{0}	43^{10}	87	11^{49}	1784	44^{60}	23^{0}	280	6^{40}
2	Γ-5770	B	79^{5}	42^{37}	46	10^{34}	1291	44^{80}	12^{5}	220	6^{35}
3	Γ-46049	A	-	38^{80}	29	10^{29}	1243	-	-	-	-
4	Γ-58128	A	80^{5}	40^{46}	88	11^{83}	1385	47^{60}	44^{0}	460	5^{22}
5	Γ-58301	A	81^{0}	40^{60}	79	11^{03}	1509	48^{20}	28^{5}	340	-
6	Γ-63848	A	80^{0}	37^{87}	57	10^{34}	1158	46^{00}	17^{5}	220	7^{32}
7	Γ-63849 (A)	A	78^{5}	34^{38}	38	9^{57}	1309	49^{00}	0^{9}	200	7^{00}
8	Γ-65874	A	79^{3}	36^{94}	70	11^{00}	1261	47^{70}	12^{5}	180	610
9	Γ-66187	B	78^{3}	37^{34}	78	10^{00}	1331	46^{60}	17^{5}	260	5^{14}
10	Γ-66287	B	80^{0}	41^{70}	82	11^{70}	1271	50^{30}	17^{0}	220	5^{04}
11	Γ-66289	B	79^{3}	4036	69	11^{12}	1349	48^{00}	15^{0}	220	5^{25}
12	Γ-66290	B	79^{3}	40^{80}	73	11^{05}	1090	49^{60}	12^{0}	220	5^{09}

Table 1d: Experimental Plot
Dhourouti

④	(1) ΠΟΙΚΙΛΙΑΙ	(2) ΕΠΙ ΣΙΤΟΥ						(3) ΕΠΙ ΣΕΜΙΔΑΛΕΩΣ			
		ΧΡΩΜΑ (4)	ΕΚΑΤΟΛΙΤΡΙΚΟΝ ΒΑΡΟΣ ΕΠΙ ΞΗΡΟΥ (5)	ΒΑΡΟΣ 1000 ΚΟΚΚΩΝ ΕΠΙ ΞΗΡΟΥ (6)	ΚΟΚΚΟΙ ΥΑΛΩΔΕΙΣ ΕΠΙ % (7)	ΠΡΩΤΕΙΝΙΚΟΝ ΠΕΡΙΕΧΟΜΕΝΟΝ ΕΠΙ ΞΗΡΟΥ (8)	ΤΕΦΡΑ ΕΠΙ ΞΗΡΟΥ (9)	ΑΠΟΔΟΣΙΣ ΕΙΣ ΣΕΜΙΔΑΛΙΝ (10)	(14) ΕΚΤΑΝΣΙΟΓΡΑΦ: ΕΝΕΡΓΕΙΑ (11)	ΜΕΓΙΣΤΟΝ ΥΨΟΣ (12)	β-ΚΑΡΟΤΙΝΗ (p.p.m.) ΕΠΙ ΞΗΡΟΥ (13)
1	ΦΘΥΣΣΙΑΣ	A	-	50^{79}	27	10^{43}	2091	-	-	-	-
2	Γ-5770	A	-	4945	28	9^{98}	1934	-	-	-	-
3	Γ-46049	A	78^{25}	48^{11}	21	9^{85}	1910	45^{5}	12^{0}	260	10^{63}
4	Γ-58128	A	81^{00}	46^{37}	44	10^{37}	1804	51^{9}	34^{0}	380	7^{33}
5	Γ-58301	B	81^{00}	43^{71}	57	10^{41}	1768	51^{4}	28^{0}	360	9^{09}
6	Γ-63848	A	77^{73}	43^{07}	15	9^{45}	1833	-	9^{3}	200	9^{46}
7	Γ-63849-(A)	A	78^{20}	43^{61}	11	9^{16}	1815	46^{9}	8^{0}	180	8^{43}
8	Γ-65874	A	79^{00}	41^{60}	16	1036	1899	51^{4}	6^{0}	200	9^{94}
9	Γ-66187	A	77^{30}	41^{99}	27	9^{67}	1915	49^{0}	11^{3}	260	11^{04}
10	Γ-66287	A	79^{50}	37^{97}	14	10^{07}	1836	50^{9}	6^{0}	200	8^{13}
11	Γ-66289	A	78^{30}	43^{76}	24	9^{99}	1980	52^{0}	11^{7}	240	11^{93}
12	Γ-66290	A	79^{50}	44^{34}	20	10^{01}	1895	48^{9}	12^{9}	240	11^{78}

Table 1e: Experimental Plot
Kopais

(5) (1) ΠΟΙΚΙΛΙΑΙ		(2) ΕΠΙ ΣΙΤΟΥ: ΧΡΩΜΑ (4)	ΕΚΑΤΟΛΙΤΡΙΚΟΝ ΒΑΡΟΣ ΕΠΙ ΞΗΡΟΥ (5)	ΒΑΡΟΣ 1000 ΚΟΚΚΩΝ ΕΠΙ ΞΗΡΟΥ (6)	ΚΟΚΚΟΙ ΥΑΛΩΔΕΙΣ ΕΠΙ % (7)	ΠΡΩΤΕΙΝΩΝ ΠΕΡΙΕΧΟΜΕΝΩΝ ΕΠΙ ΞΗΡΟΥ (8)	ΤΕΦΡΑ ΕΠΙ ΞΗΡΟΥ (9)	(3) ΕΠΙ ΣΕΜΙΔΑΛΕΩΣ: ΑΠΟΔΟΣΙΣ ΕΙΣ ΣΕΜΙΔΑΛΙΝ (10)	(14) ΕΞΤΑΝΣΙΟΓΡΑΦΙΑ: ΕΝΕΡΓΕΙΑ (11)	ΜΕΓΙΣΤΟΝ ΥΨΟΣ (12)	(13)
1	Γ-5770	B	-	43^{15}	40	9^{61}	1870	-	-	-	-
2	Γ-46049	B	-	43^{10}	58	10^{91}	1998	-	-	-	-
3	Γ-58128	B	78^{30}	43^{10}	65	12^{79}	1996	47^{8}	20^{0}	260	5^{07}
4	Γ-58301	B	79^{30}	40^{74}	57	10^{87}	1842	44^{0}	14^{0}	240	4^{78}
5	Γ-63848	A	78^{30}	41^{88}	22	9^{18}	1843	43^{7}	7^{0}	160	4^{46}
6	Γ-63849-1Α3	A	77^{00}	41^{39}	21	10^{05}	1834	43^{9}	14^{0}	220	4^{39}
7	Γ-63876	B	78^{30}	42^{73}	40	8^{30}	1869	42^{7}	7^{5}	180	4^{09}
8	Γ-66187	A	76^{30}	36^{74}	34	10^{49}	1967	49^{5}	9^{0}	200	4^{39}
9	Γ-66287	A	78^{30}	40^{72}	49	11^{98}	1888	46^{9}	13^{0}	270	8^{16}
10	Γ-66289	A	78^{00}	43^{21}	26	10^{00}	1942	47^{5}	10^{5}	220	5^{13}
11	Γ-66290	B	78^{23}	42^{00}	30	10^{06}	2000	48^{9}	11^{0}	220	6^{09}

Table 1f: Range of Certain Values of Amber Durum Wheat

(6) (1) ΠΟΙΚΙΛΙΑΙ		(2) ΕΠΙ ΣΙΤΟΥ: ΧΡΩΜΑ (4)	ΕΚΑΤΟΛΙΤΡΙΚΟΝ ΒΑΡΟΣ ΕΠΙ ΞΗΡΟΥ (5)	ΒΑΡΟΣ 1000 ΚΟΚΚΩΝ ΕΠΙ ΞΗΡΟΥ (6)	ΚΟΚΚΟΙ ΥΑΛΩΔΕΙΣ ΕΠΙ (7) %	ΠΡΩΤΕΙΝΙΚΟΝ ΠΕΡΙΕΧΟΜΕΝΟΝ ΕΠΙ ΞΗΡΟΥ (8)	ΤΕΦΡΑ ΕΠΙ ΞΗΡΟΥ (9)	(3) ΕΠΙ ΣΕΜΙΔΑΛΕΩΣ: ΑΠΟΔΟΣΙΣ ΕΙΣ ΣΕΜΙΔΑΛΙΝ (10)	(14) ΕΞΤΑΝΣΙΟΓΡΑΦΙΑ: ΕΝΕΡΓΕΙΑ (11)	ΜΕΓΙΣΤΟΝ ΥΨΟΣ (12)	% Β. Καροτίνιον (p.p.m.) ἐπὶ ξηροῦ (13)
1	Γ-5770	A-B	$76^{5}-80^{0}$	$38^{79}-50^{51}$	28-88	$9^{61}-11^{82}$	1.291-1.934	$44^{8}-53^{2}$	$12^{0}-19^{5}$	220-320	$5^{16}-7^{49}$
2	Γ-46049	A-B	$77^{7}-80^{0}$	$38^{80}-48^{49}$	21-85	$9^{28}-10^{91}$	1.243-1.998	$49^{5}-52^{0}$	$12^{0}-36^{0}$	260-380	$5^{19}-10^{6}$
3	Γ-58128	A-B	$77^{5}-81^{0}$	$40^{14}-48^{10}$	44-95	$10^{57}-13^{70}$	1.383-1.984	$47^{3}-52^{0}$	$20^{0}-51^{0}$	260-480	$4^{72}-5^{22}$
4	Γ-58301	A-B	$76^{5}-81^{5}$	$38^{10}-48^{10}$	57-91	$10^{41}-12^{36}$	1.509-1.842	$44^{0}-52^{3}$	$14^{0}-40^{0}$	240-420	$4^{76}-9^{09}$
5	Γ-66187	A-B	$76^{5}-78^{5}$	$33^{34}-43^{30}$	27-92	$9^{67}-11^{54}$	1.351-1.967	$44^{6}-50^{0}$	$9^{0}-19^{5}$	200-340	$4^{33}-11^{0}$
6	Γ-66289	A-B	$78^{0}-80^{0}$	$39^{85}-47^{75}$	20-92	$9^{91}-13^{57}$	1.301-1.980	$44^{4}-52^{0}$	$10^{5}-20^{5}$	220-320	$4^{76}-11^{9}$
7	Γ-66290	A-B	$78^{2}-80^{5}$	$40^{80}-54^{71}$	20-94	$10^{01}-12^{79}$	1.090-2000	$42^{2}-51^{5}$	$11^{0}-21^{0}$	220-300	$5^{89}-11^{7}$
Διάφοροι C.W.											
8	AMBER-DURUM Καναδᾶ (15)	B	79-83	39-40	60-95	$15^{0}-17^{0}$		50^{0}			$4^{5}-6^{5}$
9	Σκληρός Ἰσπανίας τελευταίας εἰσαγωγῆς (16)	B	79^{5}	56^{0}	65		1837	44^{8}	41^{5}	420	7^{22}

Table II a: Experimental Plot
Thessaloniki

% (7)	(29)	(30)	(4)	(5)	(6)	(17)	(7)	(8)	(9)	(10)	(11)	(12)	(14)
						Α. ΑΝΕΥ ΛΙΠΑΝΣΕΩΣ							
1ος	24/5	A1 A9 B3 B10	A B B B	41^0	[illegible] 77^1 78^9 74^2	35^{92} 35^{48} 35^{14} 35^{40}	77 92 89 88	13^{71} 16^{33} 13^{77} 14^{49}	1630 1556 1697 1999	46^1 44^4 41^4 44^9	22^9 48^3 36^9 72^5	320 440 380 440	6^{96} 7^{41} – 8^{40}
2ος	30/5	A5 B6	B B	23^0	77^5 73^5	35^{44} 35^{36}	84 89	[illegible] 15^{41}	1721 1675	45^7 46^3	38^1 65^0	340 300	7^{94} 6^{81}
3ος	1/6	A3 A11 B8	B B B	17^0	76^5 76^3 76^5	36^{76} 36^{40} 37^{44}	85 89 89	12^{17} 15^{81} 15^{44}	1697 1719 1767	43^0 44^6 43^2	51^0 62^5 71^0	340 540 340	7^{85} 7^{76} 7^{55}
4ος	13/6	A7 B4 B12	A B B	10^8	78^2 74^0 75^5	37^{00} 36^{38} 37^{35}	86 81 80	11^{37} 13^{81} 11^{31}	1544 1617 1994	45^3 44^4 44^4	39^5 47^5 59^0	360 400 500	6^{51} 6^{61} 7^{35}
						(18) Αι ΜΕΤΑ ΛΙΠΑΝΣΕΩΣ							
1ος	26/5	A6 B5	A B	41^0	77^0 76^5	32^{63} 34^{98}	87 90	16^{20} 18^{10}	1400 1366	43^3 43^1	53^0 66^0	320 300	5^{66} 5^{43}
2ος	30/5	A2 A10 B1 B9	A B A B	23^0	76^5 75^0 78^0 73^0	35^{76} 35^{12} 37^{01} 35^{00}	85 90 85 81	15^{37} 16^{33} 16^{71} 15^{14}	1503 1599 – 1663	46^2 43^5 43^3 43^0	53^0 62^9 59^0 100^0	420 400 320 600	5^{37} 5^{71} 5^{76} 5^{79}
3ος	1/6	A4 A12 B7	B B B	17^0	76^3 75^4 76^3	36^{04} 31^{79} 36^{75}	78 84 88	15^{26} 16^{19} 16^{40}	1417 1823 1621	46^2 47^0 41^7	56^0 68^0 75^0	460 440 360	5^{37} 6^{04} 5^{06}
4ος	13/6	A8 B11 B3	B B B	10^8	76^0 73^5 73^0	35^{36} 29^{89} 37^{13}	77 86 90	12^{84} 14^{78} 15^{38}	1640 1783 1462	43^9 43^0 44^3	52^0 72^0 79^0	420 560 600	5^{56} 5^{30} 5^{81}
(7)													

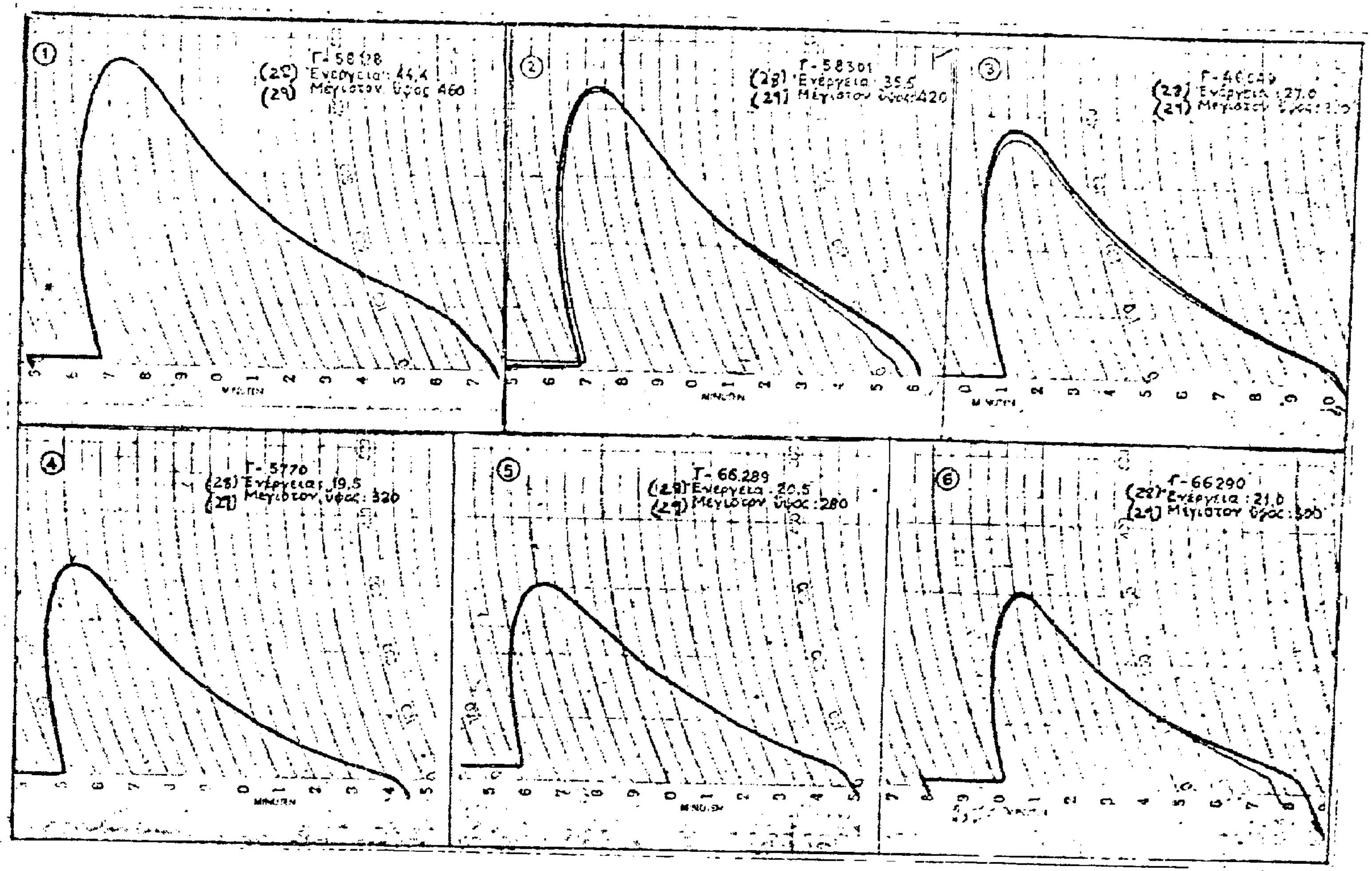
Table II b: Experimental Plot
Nea Zoi

%			ΣΠΟΡΑ (4)	(5)	(6)	(17)	(7)	(8)	(9)	(10)	(11)	(12)	(14)
						Α. ΑΝΕΥ ΛΙΠΑΝΣΕΩΣ							
1ος	5/6	A1 A3 B2	B B B	39^4	76^5 77^0 76^0	43^{40} 45^{36} 45^{88}	86 80 91	14^{36} 14^{70} 1516	1960 1970 2285	48^8 45^9 50^9	52^0 53^0 54^0	400 450 440	7^{99} 7^{36} 7^{18}
2ος	9/6	A3 B4 B6	B B B	23^0	75^5 75^0 76^5	44^{29} 45^{45} 45^{70}	90 90 85	14^{17} 16^{06} 13^{36}	2091 2147 2021	47^3 44^0 41^8	58^0 54^7 51^0	440 400 440	6^{74} 6^{90} 7^{11}
3ος	12/6	A7 A8 B8	B B B	14^1	75^5 75^5 76^5	45^{15} 44^{63} 45^{24}	83 93 84	14^{18} 12^{70} 13^{42}	2044 1966 1792	45^0 46^1 44^1	57^0 53^5 50^5	460 420 460	6^{86} 7^{19} 6^{77}
4ος	22/6	A11 B10 B12	B B B	11^0	77^0 76^0 75^7	43^{31} 45^{45} 45^{36}	87 79 79	11^{93} 14^{00} 13^{60}	1843 1755 1649	45^4 45^0 44^2	56^5 50^3 37^0	340 360 340	6^{40} 6^{45} 7^{94}
						(18) Αι ΜΕΤΑ ΛΙΠΑΝΣΕΩΣ							
1ος	5/6	A2 B1 B3	B B B	39^4	76^7 75^0 74^0	43^{96} 42^{87} 44^{88}	91 90 88	14^{75} 16^{61} 16^{48}	2036 1900 2188	48^7 46^7 –	57^0 58^7 54^0	410 400 420	6^{25} 6^{36} 6^{17}
2ος	9/6	A4 A6 B5	B B B	23^0	74^5 76^0 74^5	42^{34} 44^{94} 42^{91}	98 92 86	15^{05} 15^{63} 15^{42}	2079 1725 2084	46^7 47^2 45^8	72^3 64^0 59^3	580 500 500	5^{33} 6^{00} 6^{36}
3ος	12/6	A8 B7 B9	B B B	14^1	75^0 76^0 76^2	45^{15} 43^{85} 42^{81}	90 88 86	14^{79} 13^{96} 14^{69}	2098 1895 1949	44^7 42^7 44^3	59^0 48^0 72^0	540 440 520	5^{81} 6^{18} 6^{21}
4ος	22/6	A10 A12 D11	B B A	11^0	74^0 76^0 73^7	44^{95} 46^{94} 45^{60}	91 90 77	13^{73} 14^{81} 13^{09}	1962 [illegible] 1857	47^6 41^5 43^0	43^0 35^0 43^0	380 340 400	5^{65} 5^{99} 5^{86}

Table II c:

(9) (31) ΧΑΡΑΚΤΗΡΕΣ	ΑΝΕΞΑΡΤΗΤΩΣ ΘΕΡΙΣΜΟΥ (25)			ΚΑΤΑ ΘΕΡΙΣΜΟΥΣ (Λο) ΑΝΕΥ ΛΙΠΑΝΣΕΩΣ (26)					ΚΑΤΑ ΘΕΡΙΣΜΟΥΣ (Λ1) ΜΕΤΑ ΛΙΠΑΝΣΕΩΣ (27)				
	Λο	Λ1	SSD	1ος	2ος	3ος	4ος	SSD	1ος	2ος	3ος	4ος	SSD
(11) Α' ΠΕΙΡΑΜΑΤΙΚΟΣ ΚΕΝΤΡΙΚΟΥ													
(21) Υαλώδεις κόκκοι	86	85	NS	86.5	86.5	87.7	82.3	NS	86.0	85.2	84.0	84.3	NS
(22) Πρωτεϊνικόν σύνολον	13.47	15.83 +++	5% 1.134 1% 1.225	14.21	14.15	13.35	12.18	NS	17.21	16.19	15.94	14.23	NS
(23) Έκτανσιογραφ. ενέργεια	49.5	64.46 +	5% 16.32	45.0	51.7	54.8	48.7	NS	59.5	63.5	65.8	67.6	NS
(24) Β. Καροτίνιον (p.p.m.)	7.52	5.46 ++	5% 0.478 1% 0.658	8.16	7.40	7.55	6.96	NS	5.55	5.45	5.45	5.49	NS
(20) Β' ΠΕΙΡΑΜΑΤΙΚΟΣ Ν. ΖΩΗΣ													
(21) Υαλώδεις κόκκοι	86	89	NS	86	88	87	82	NS	90	92	88	86	NS
(22) Πρωτεϊνικόν σύνολον	13.98	15.0 ++	5% 0.154 1% 0.213	14.81	14.53	13.39	13.19	NS	16.07	15.47	14.48	14.02	5% 1.29 1% 1.88
(23) Έκτανσιογρ. ενέργεια	48.7	55.8 ++	5% 4.81 1% 6.63	53.0	54.5	53.3	34.0 ++	5% 5.54 1% 8.06	56.5	66.7	59.7	40.3 ++	5% 1.38 1% 2.01
(24) Β. Καροτίνιον (p.p.m.)	7.21	5.97 ++	5% 0.411 1% 0.567	7.67	6.85	7.38	6.96	NS	6.26	5.90	6.10	5.63	NS

REPRESENTATIVE DIAGRAMS OF CERTAIN VARIETIES



[Legend:] 1) Varieties; 2) Experiments on Wheat; 3) Experiments on Semolina; 4) Color; 5) 100-liter Weight; 6) 1,000 Kernal Weight, Dry Analysis; 7) % of Crystalline Kernels; 8) Protein Content, Dry Analysis; 9) Ash Content, Dry Analysis; 10) Semolina Yield; 11) Energy; 12) Greatest Height; 13) B Carotene (p.p.m.), Dry Analysis, 14) Experiments on Semolina; 15) Various C. W. (Canadian wheats), Amber Durum, Canada, 16) Spanish Durum from latest imports; 17) Data Without Fertilizers; 18) Data After Application of Fertilizers; 19) Data Collected from "Kentrikou" plot; 20) Data Collected from "Nea Zoi" plot, 21) Crystalline Kernels; 22) Protein Content; 23) Extansiographic Energy; 24) B. Carotene (p.p.m.); 25) Date Independent of Harvest; 26) Data of Harvest Without Fertilizer; 27) Data of Harvest With Fertilizer; 28) Harvests; 29) Date; 30) Repetitions; 31) characteristics.

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